

April 16, 1968

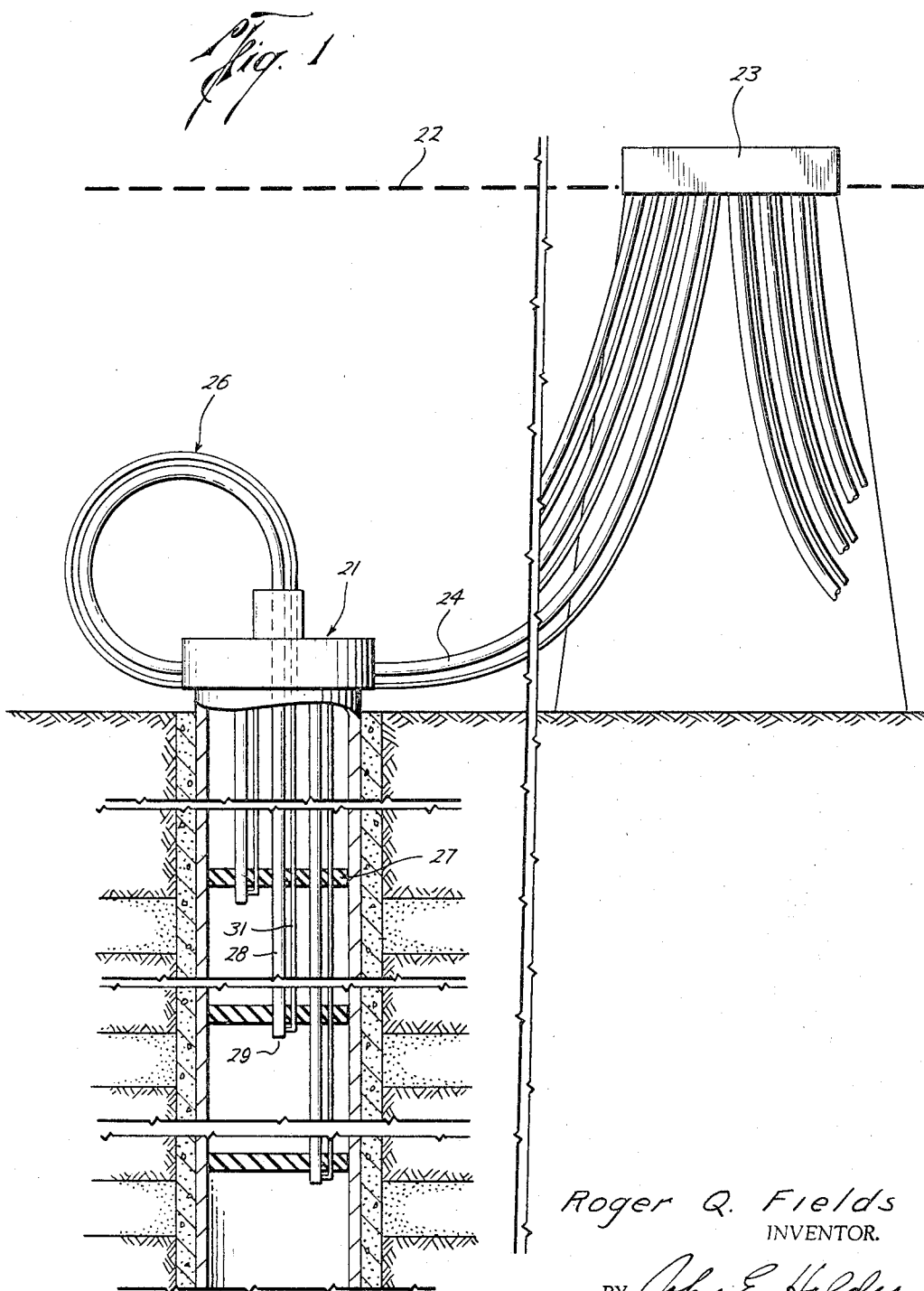
R. Q. FIELDS

3,378,069

WELL MAINTENANCE AND COMPLETION TOOLS

Filed Aug. 13, 1964

6 Sheets-Sheet 1



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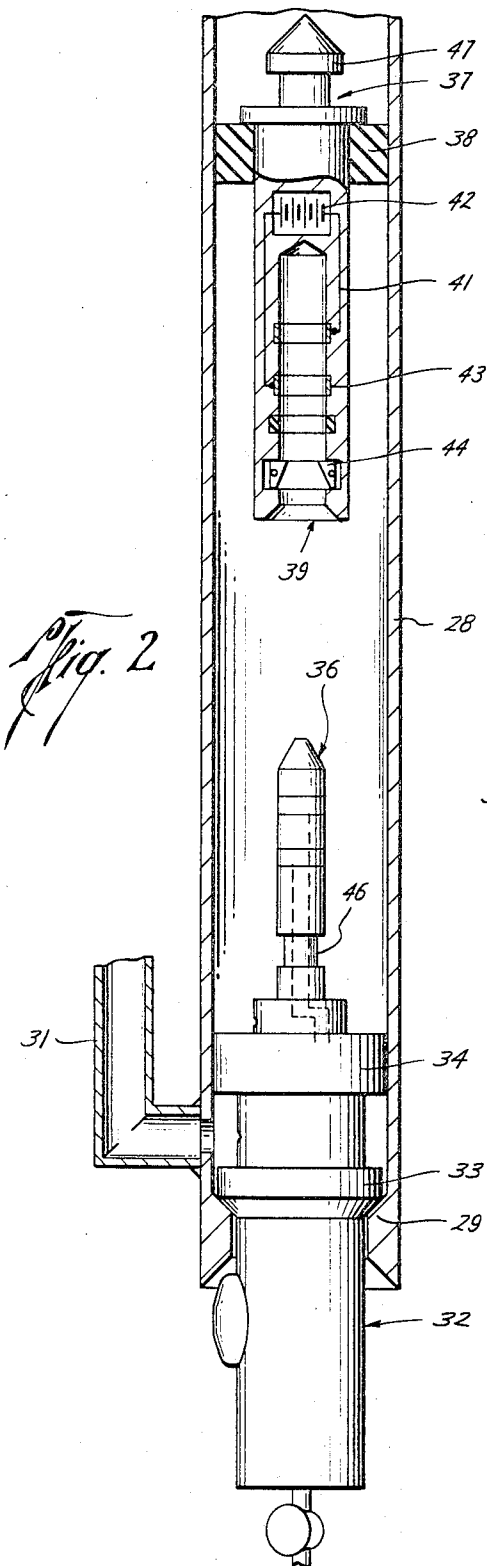
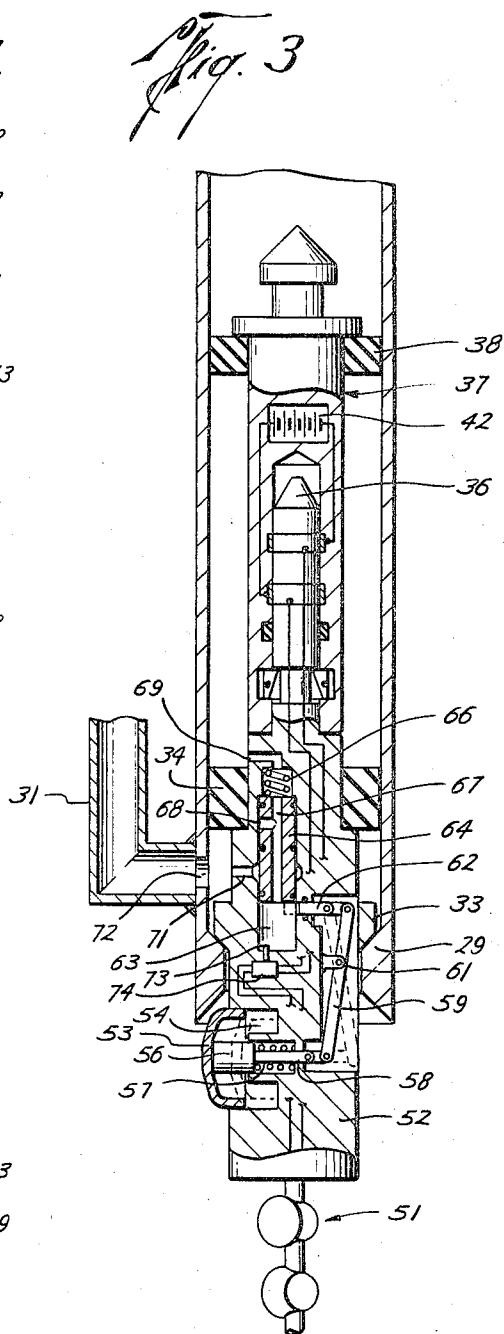
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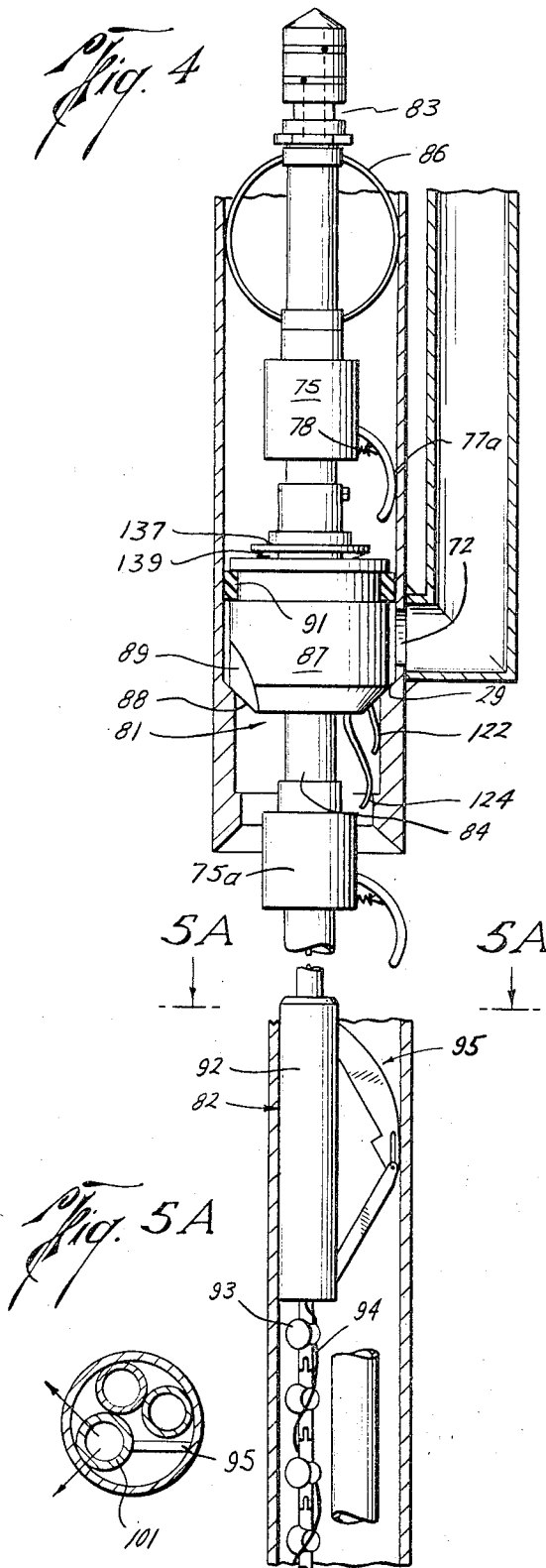
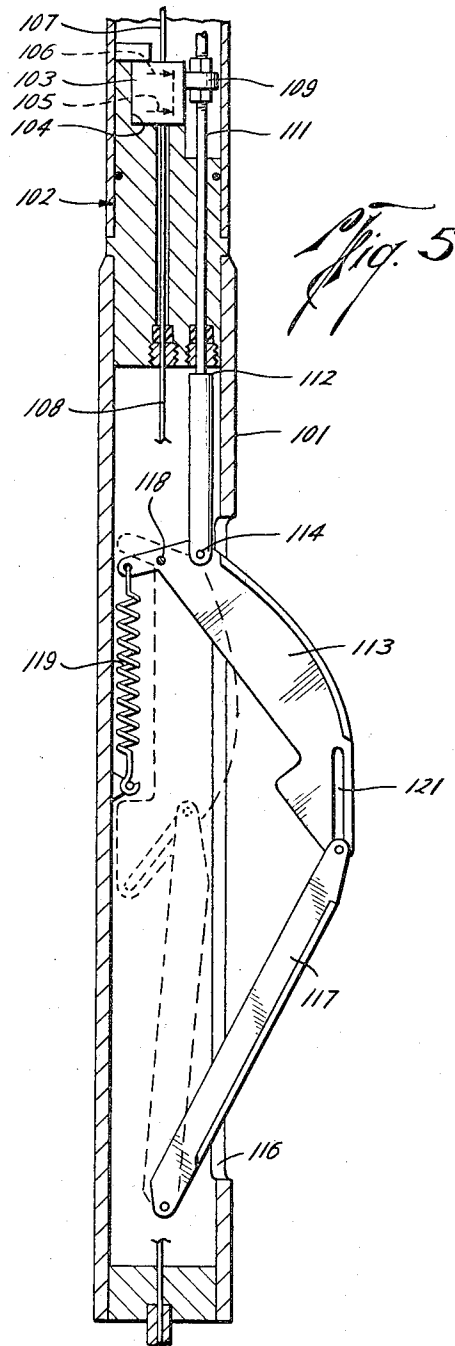
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6 Sheets-Sheet 3



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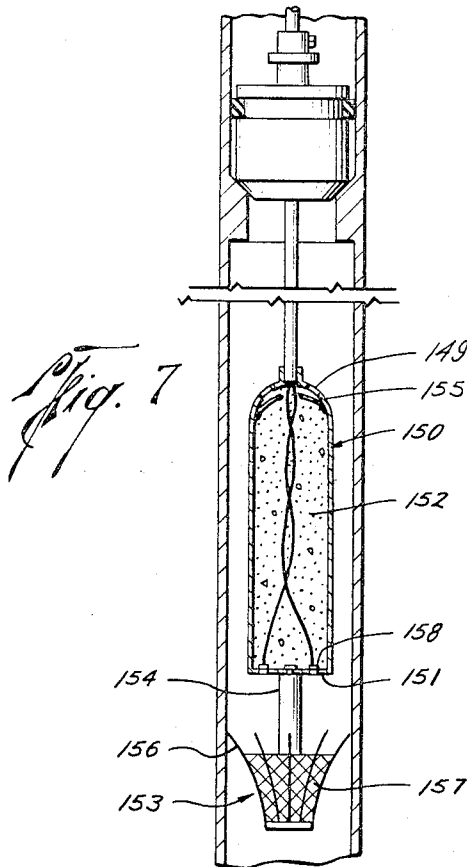
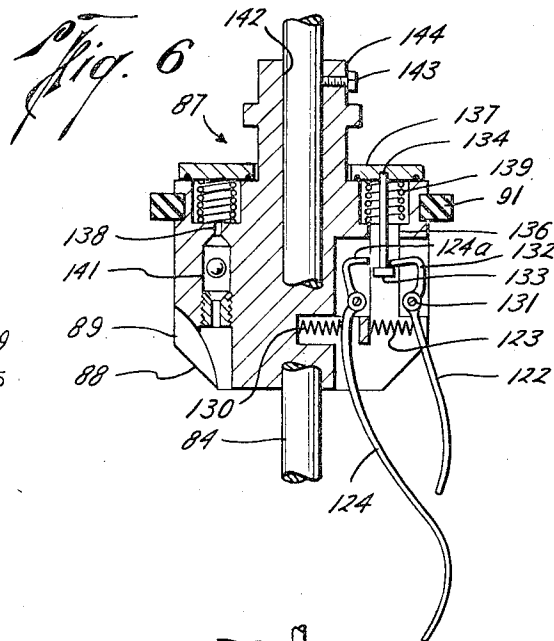
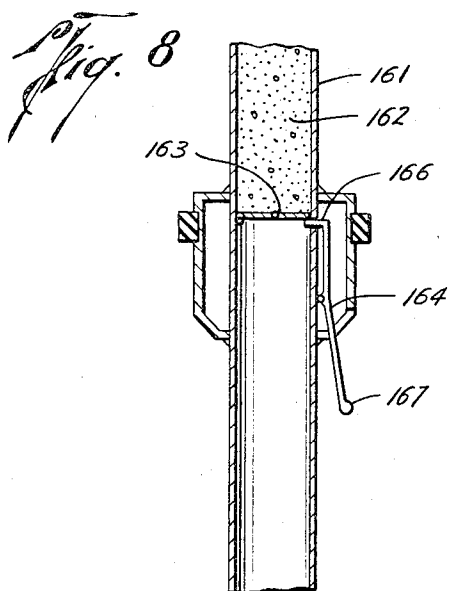
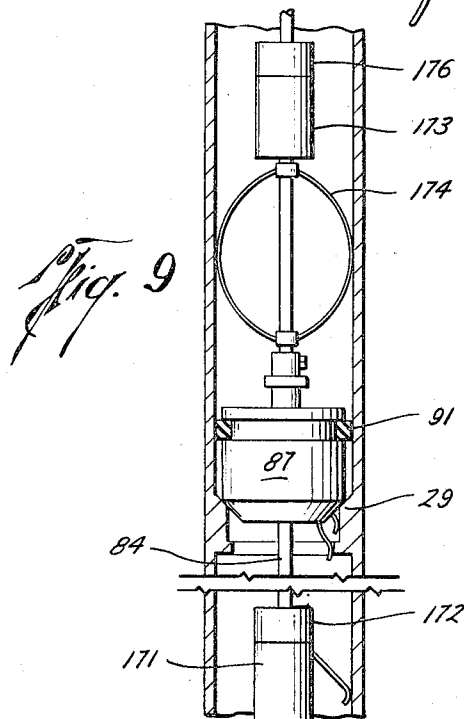
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Fig. 10

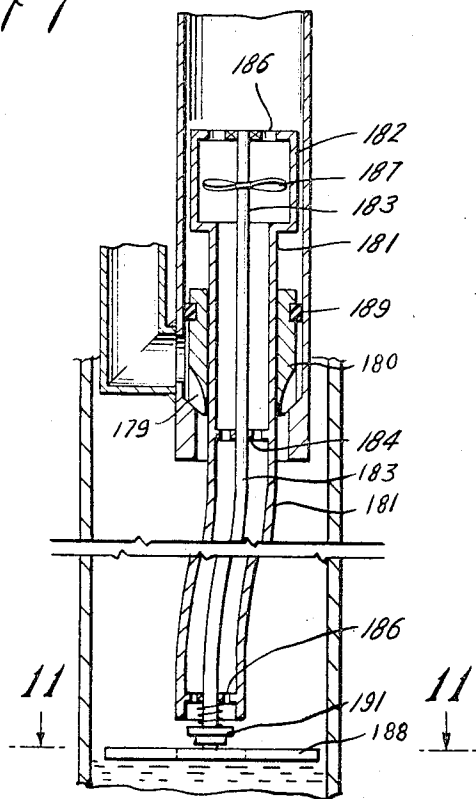


Fig. 12

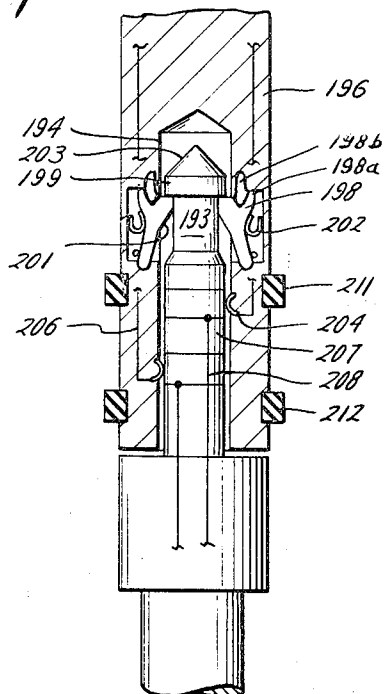


Fig. 11

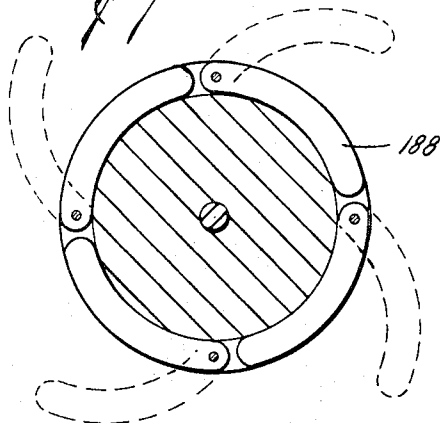
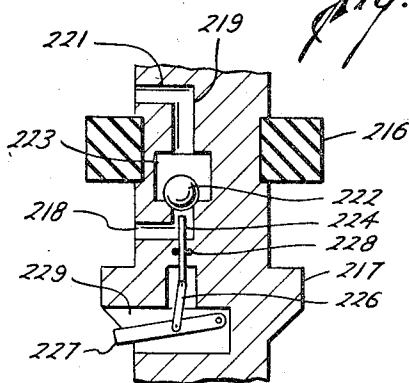


Fig. 13



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Filed Aug. 13, 1964

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Fig. 14

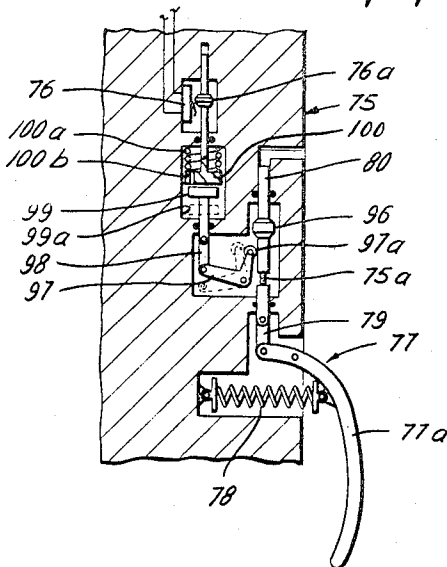


Fig. 15

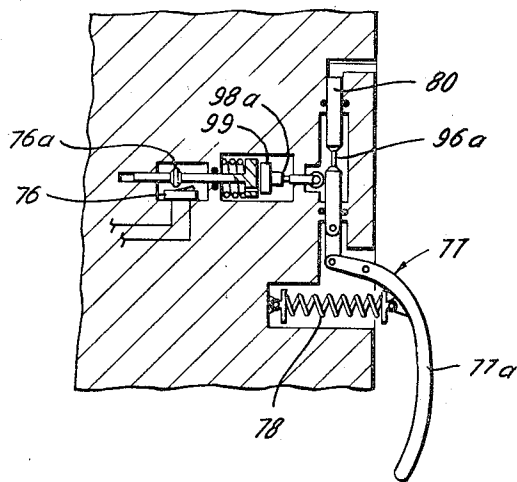
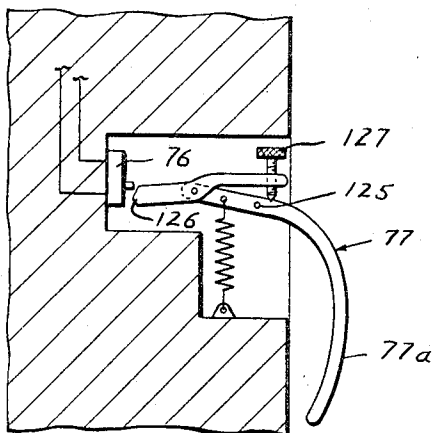


Fig. 16



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3,378,069

WELL MAINTENANCE AND COMPLETION TOOLS
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Filed Aug. 13, 1964, Ser. No. 389,389
25 Claims. (Cl. 166-4)

ABSTRACT OF THE DISCLOSURE

As exemplary of certain embodiments of the invention disclosed herein, various well-completion tools are arranged for passage through a flow line into position for performing a completion operation in a well bore. Various apparatus are included for providing indications at the surface when the tool is in position as well as to prevent premature actuation thereof.

Accordingly, as will subsequently become apparent, this invention relates to well tools and, more particularly, to well-servicing tools which are capable of being pumped into and out of flow lines connected to an underwater wellhead assembly.

A system has been developed for offshore wells which utilizes a central gathering station having several wells spaced therefrom and flow lines connecting the central gathering station with the wellhead assemblies located on the floor of the body of water. These flow lines, which may be of considerable length, run horizontally along the ocean floor to the wellhead assembly at which point a loop is formed in the flow pipe before connecting to the wellhead assembly. These loops are of a sufficient diameter to permit the passage of flexible tools through the tubing around the radius and into the well tubing string. Therefore, instead of using conventional floating rigs for service jobs to be performed on the wells, well-service tools are pumped through the flow line from the central gathering platform. Well tools utilized in such a system must be of such flexibility as to be capable of being pumped through the flow line around the radius in the flow line and into the tubing string. Virtually all tools presently run on wire lines may be adapted to such a system including perforating, logging, cementing, and various other maintenance or work-over tools.

Since no mechanical connection is maintained with these tools which are pumped "through the flow line" (TFL), it is extremely important that the position of the tools in the tubing be known so that the work may be performed at the desired depth. Additionally, it is preferable that tools which normally contain explosive charges, such as perforating devices, be incapable of being fired until they have been positioned at the desired depth in the well.

It is, therefore, an object of the present invention to provide new and improved apparatus for performing various operations in a well wherein the apparatus may be pumped into and out of the well through a flow line.

Another object of the present invention is to provide new and improved apparatus for positioning a perforating device in a well having an underwater wellhead assembly and safely conditioning the device for actuation at such a position.

Still another object of the present invention is to provide new and improved apparatus for running perforating devices into a well having an underwater wellhead assembly and subsequently positioning an activating device in the well to energize the perforating device.

A further object of the present invention is to provide new and improved apparatus for giving an indication that well tools have obtained a known position in a well bore.

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With these and other objects in view, the present invention contemplates various apparatus for completing and maintaining wells having underwater wellhead assemblies positioned at or near the ocean floor by utilizing tools pumped into and out of the well through the flow line. More particularly, the apparatus includes means for rendering the tools operative only upon their reaching a predetermined position in the tubing string. Another apparatus forming a part of this invention includes a system for conditioning a perforating device for firing only after it has been positioned at a predetermined location in the tubing string.

A complete understanding of this invention may be had by reference to the following detailed description when read in conjunction with the accompanying drawings illustrating an embodiment thereof, wherein:

FIG. 1 shows an underwater wellhead assembly connected to a gathering platform by flow lines;

FIGS. 2 and 3 are elevational views showing a section of tubing string with a perforating gun and messenger activating apparatus positioned therein;

FIG. 4 shows an apparatus for locating and orienting a perforating device in a well bore, the view below the broken line being at a small scale;

FIG. 5 is a detailed view of the orienting apparatus shown in FIG. 4;

FIG. 5A is a cross-sectional view of the reduced scale portion of FIG. 4 showing the orienting apparatus positioned in a casing having 2 strings of tubing therein;

FIG. 6 is a vertical section of positioning apparatus and hydraulic indicator capable of being pumped through a flow line;

FIG. 7 is a combination bridge plug and cement dump bailer for cementing a well;

FIG. 8 is an elevational view of a dump bailer capable of being pumped through a flow line into an underwater well;

FIG. 9 is an elevational view of a logging apparatus;

FIG. 10 is an elevational view of a sand reamer;

FIG. 11 is a cross-sectional view taken along line 11-11 of FIG. 10 showing the agitating members on the reamer;

FIG. 12 is a detailed view of another latch device and contact for use in the messenger apparatus shown in FIG. 2;

FIG. 13 is a detailed view of a position indicating device; and

FIGS. 14, 15 and 16 are partial views showing different embodiments of a safety switch device.

Referring first to FIG. 1, a wellhead assembly 21 is shown positioned beneath the surface 22 of a body of water over a well bore. A gathering or production platform 23 is positioned at the surface some distance from the well and a pair of flow lines 24 run from the platform to the wellhead 21 for each production zone completed in the well. A loop 26 is formed in the flow lines 24 as they enter the wellhead 21 to bring the flow lines 24 into the wellhead in a vertical direction, with the loop being of a sufficient diameter to permit the passage of flexible TLF tools around the loop and into the wellhead. For the purposes of illustration, FIG. 1 shows the well having three completed formations with packing devices 27 separating the various producing zones. A pair of pipes is suspended from the wellhead assembly to each producing zone with each of these pipes being connected to a separate one of the flow lines 24 by suitable valves at the wellhead. The larger pipe 28 represents the producing string and has at least one seating or landing nipple 29 located at or near its lower end. Another pipe 31, running parallel with the producing string, is connected to the producing string at its lower end above the lowermost landing seat. This second pipe 31, hereinafter referred to

as the circulating or bypass conduit, provides a means for reverse circulation through the first pipe or producing string. This circulation system provides a means for obtaining positive circulation to a given zone and for powering devices to lift formation fluids to the surface. The system also provides a means for pumping TFL tools into and out of wells completed underwater.

While not shown in FIG. 1, the housing comprising part of the wellhead assembly 21 contains various valves for regulating the flow of fluid into and out of the producing and bypass strings 28 and 31 in the well.

Referring now to FIG. 2, the lower end of the producing pipe or flow line 28 is shown with the circulating conduit 31 connected to the producing string near its lower end. The landing nipple 29 which is positioned at the bottom of the producing pipe is shown supporting a TFL tool 32. A flange 33 formed on the tool is shaped to be compatibly received on the landing nipple 29. A seal element or swab 34 positioned on the tool 32 above the seating flange 33, provides a fluid-tight seal between the tool and producing pipe 28 so fluid pressure can be used to pump the tool 32 through the pipe. When the tool reaches the landing nipple in the producing string and seats therein, a bypass valve in the tool is opened to provide for fluid flow through the tool around the seal element. An electrical plug element 36 is shown extending upwardly from the tool and seal element.

Above the tool 32 in the pipe 28, a messenger apparatus 37 is shown also having a seal member 38 thereon engaging the wall surface of the producing pipe. Again, this seal member permits fluid pressures applied selectively above or below the messenger apparatus 37 to move the messenger through the producing string. The bypass valve provided in the tool 32 permits fluids to bypass the tool to facilitate the pumping-in of the messenger after the tool is seated on the landing nipple. The messenger apparatus also has an electrical socket 39 therein having contacts 43 which are connected by wires 41 to power source 42. A flexible split ring latch member 44 is positioned around the interior wall of the socket 39 and becomes expanded over the upwardly extending plug member 36 on the tool 32 when the connector members are coupled. Upon full engagement of the connector members, the latch member 44 contracts into a recess 46 in the plug 36 on the tool. An undercut neck member 47 extends upwardly from the messenger 37 to provide an engaging means for other devices which may be pumped into the producing pipe above the messenger.

FIG. 3 shows the apparatus set forth in FIG. 2 with the messenger device 37 coupled to the tool to provide a source of electrical power to the tool. The tool is represented in FIG. 3 as including a perforating gun 51 which plunger element 53 in a recess 54 in the housing 52 will be extended once the lower end of the tool passes through the landing nipple into a larger casing bore. The plunger element, in turn, is connected to one end of a spring-loaded guide member 56 received within a chamber 57 in the tool. A horizontal piston rod 58 is connected between the other end of the guide member 56 and one end of a vertical linking member 59 pivotally connected at pivot point 61 to the housing. The upper end of the linking member 59 is connected to an upper rod 62 which rod is reciprocally received into the side of a longitudinal bore 63. A valve member 64 having spaced sealing members thereon is slidably received within the cylindrical bore 63 and normally held in an upward position therein so long as the upper rod 62 is protruding into the side of the bore. A spring 66 is positioned above the valve member 64 to provide a downward bias thereon. A vertical passageway 67 through the valve member 64 provides a balanced valve and is intersected by a lateral passageway 68 terminating between two of the sealing members around the valve member. An entrance port or passageway 69 is

formed through the upper end of the tool housing to provide for fluid flow between the outside of the tool above the seal element 34 and the upper end of the bore 63. An exit port or passageway 71 extends from a point near the middle of the vertical bore 63 to the outside of the tool housing below the seal member 34. The seal member 34 is positioned on the housing at a point sufficiently above the flange 33 to maintain the seal above an opening 72 in the producing pipe wall which communicates with the bypass conduit 31 when the tool 32 is seated.

A plunger 73 is positioned in the lower end of the bore 63 for actuating a normally open switch 74 which, in turn, is connected into an electrical circuit extending through the tool from the upwardly extending plug member 36 to the perforating gun 51 below the tool. Thus, as the tool 32 enters the seat 29, the extension of the plunger 53 will retract the rod 62 and release the valve member 64 to close the switch 74 and complete the electrical circuit between the power source 42 and the gun 51.

In the operation of this apparatus, when it is desired to perform perforating operations within the well bore or casing, the perforating tool 32 is inserted in the flow line at the gathering platform shown in FIG. 1. Subsequently, when fluid pressure is applied to the flow line 24, the tool is pumped through the flow line and into the producing pipe 28 positioned in the well. Fluid in front of the tool is permitted to escape through the bypass conduit 31. When the tool reaches the lower end of the production pipe, the perforating gun portion extending from the tool passes through the landing nipple 29. The perforators 51 are suspended by a cable or other flexible means from the tool, with its length being adjusted to maintain the perforators at a distance from the landing nipple corresponding to the depth below the landing nipple of the formation to be perforated. While the tool is being pumped through the pipe to its landing position in the nipple 29, the plunger element 53 slidably received in the side of the tool is retracted due to the restricted diameter of the flow line and producing pipe condition as element and linkage mechanism is shown by the phantom lines in FIG. 3. With the linkage in this position, the upper rod 62 extends into the side of the bore 63 to maintain the valve member 64 positioned in the upper end thereof. This places two of the seal members on the valve member 64 on either side of the exit port or passageway 71 in the tool, thereby blocking off the passageway 71 from fluid communication with the vertical passageway 67 in the valve member and the entrance port 69 connecting to the outside of the well tool above the seal. Therefore, no circulation is permitted around the seal member 34 until the tools reach the landing nipple and the plunger element 53 has passed through the nipple into the enlarged well bore. Upon reaching this enlarged area the compressed plunger element is caused to extend outwardly into the well bore under the force of the spring positioned behind the piston 56. This expansion of the plunger into the well bore moves the attached piston and piston rod 58 to the left as shown by the heavy lines in FIG. 3. This, in turn, pivots the vertical arm 59 about the pivot 61 to withdraw the upper rod 62 from the vertical bore 63 and allows the valve member to move downwardly under the force of spring 66 thereabove. This downward movement of the valve member brings the lateral passageway 68 in the piston wall into alignment with the exit port 71 in the tool housing to provide for fluid flow between the space above the tool seal to a point in the production pipe below the seal which is in communication with the opening or flow port 72 in the pipe communicating with the bypass conduit 31. When the tool seats in the landing nipple, a predetermined pressure indication (increase in pressure) is received at the surface that the tool has seated at the bottom of the producing pipe and that the perforating gun is properly positioned. The flow port 72, when opened, permits fluids to bypass through the con-

duit 31 thereby limiting this pressure increase above the tool. Therefore, if the tool is not seated in the landing nipple but rather has been stuck at a bridge in the pipe, the lateral passageway 68 will not have opened to the port 71 thus giving an indication (continuous pressure build up) that the tool is not properly seated in the landing nipple.

Additionally, when the valve member 64 moves downwardly to the lower end of the bore 63, the plunger 73 of the normally open electrical switch 74 is actuated by this downward movement of the valve member to close the circuit through the tool. This furnishes a safety arming device for the perforating gun.

After the tool is seated in the landing nipple, the messenger apparatus 37 which contains the power source 42 is placed in the flow line at the producing platform and pumped through the flow line and into the producing string in the same manner as the tool. When the messenger reaches the lower end of the production pipe, the connecting socket 39 of the messenger engages the plug member 36 extending upwardly on the tool. This provides an electrical connection between the power source 42 in the messenger and the perforating gun circuit thereby activating the perforating device.

It should be noted that an electrical cable could be provided between the messenger and a power supply at the gathering station so that it would require activation of the circuit through this electrical connection to fire the perforating gun. Alternatively, the power source messenger and perforating tool could be connected before pumping through the flow line, thereby depending upon the normally open switch 74 in the tool to prevent premature firing.

FIG. 4 shows a tool assembly 81 including a perforating portion 82, the assembly being constructed so as to be capable of being pumped through the flow line of an underwater well. The top part of the tool assembly 81 has a connector plug 83 for engagement with the messenger apparatus heretofore described. Directly below this plug portion is a centralizer 86 to centrally locate the tool and connector in the tubing thereby assuring proper orientation of the connector plug 83 of the tool for connection with the messenger. A safety switch portion 75 of the tool is shown below the centralizer 86. A flexible cable 84 is connected to the lower end of the safety switch and extends downwardly therefrom. Another safety switch portion 75a is shown connected to the cable 84. A positioning tool 87 is slidably mounted upon the cable 84 between the upper and lower safety switch portions.

The operating portion of this safety switch tool is shown in greater detail in FIG. 14. Electrical circuit wires which extend from the connector plug 83 on the upper safety switch portion are attached to a switch 76 (FIG. 14) at the upper end of the safety switch portion. This switch serves to open and close the circuit which extends from the connector plug 83 to perforating charges 93 at the lower end of the tool assembly. A switch arm 77 is pivotally connected to the lower end of the safety switch portion, the arm having an arcuate portion 77a extending outwardly from the tool body. A spring 78 is positioned between the tool housing and the arm to bias the arm outwardly from the tool into engagement with the interior wall surface of the producing string of pipe. The upper end of the arm is connected through a linkage 79 to the lower end of a cam rod 80. An enlarged portion 96 on the cam rod serves to pivot a rocker arm 97 which is pivotally connected to the safety switch housing. One end of the rocker arm is connected through a linkage mechanism 98 to a switch rod base 99 that is slidably received in a bore 99a thus, as the enlarged portion 96 of the cam rod engages the rocker arm, the rocker arm is pivoted to move the base 99 downwardly as shown by the phantom lines in FIG. 14. A switch plunger 100 is also positioned in the bore 99a and rests upon the base 99. A

spring 100a biases the plunger 100 against the base. An orifice 100b is formed in the plunger which provides for fluid flow from one side of the plunger to the other when the plunger moves through the cylinder. A switch actuator cam 76a is positioned on the upper end of the plunger and serves to close the switch 76.

The safety switch portion of the tool described above operates as follows: The switch arm 77 is biased into contact with the interior wall surface of the production tubing as the tool is pumped into the well through the tubing. The contact of the arm with the wall of the tubing, in turn, transmits the motion of the arm 77 caused by differentials in the diameter of the tubing wall to the cam rod 80 through the linkage 79. The rod 80 reciprocates up and down due to the changing diameters engaged in the tubing. At a certain diameter determined by the position of the enlarged portion 96 on the rod 80, the enlarged portion engages a roller 97a on the rocker arm 97 and pivots the rocker to the position shown in the phantom line. This motion in turn is transmitted through linkage 98 to base 99 and lowers base 99 to the position shown in the phantom lines.

The spring 100a pushes the plunger 100 downwardly in the cylinder 99a with fluid passing from one side of the plunger to the other through orifice 100b in the plunger to retard the movement of plunger 100. If the diameter of the pipe is constant at this point, the linkages will remain in the position indicated by the phantom lines and the plunger 100 will continue to move downwardly in the cylinder 99a until it again rests on the base 99 in the lower position. At this point the switch actuator cam 76a will close the switch and complete a circuit through the wires connected thereto. It should be noted that an adjustment screw and lock nut 75a is provided on the lower end of the cam rod 80 to provide an adjustment of the mechanism to close the switch at selected internal pipe diameters.

A similar safety switch apparatus is shown in FIG. 15. This apparatus however has a depressed or notched portion 96a on the rod 80 for providing motion to the base 99 through follower arm 98a. It will be readily seen that the dash pot and switch arrangement will operate in the same manner as set forth with respect to the operation of the apparatus shown in FIG. 14.

FIG. 16 also shows a safety switch apparatus similar to that shown in FIGS. 14 and 15, but not having a dash-pot mechanism. An arm 77 is pivotally connected to the body portion of the tool by a pivot pin 125. A tension spring is attached to the arm in order to urge the arcuate-shaped portion 77a of the arm 77 outwardly from the tool. A cam portion 126 formed on the end of the arm is shaped to engage a contact element on the switch 76 when the arm is expanded within a certain size diameter of tubing. This cam portion is adjustable by the screw 127 to vary the diameter of tubing at which the switch will be engaged by the cam.

Referring again to FIG. 4, the position indicator portion 87 of the tool has a frusto-conical portion or seat 88 at its lower end providing a seat for the tool in the landing nipple 29. This seat is cut away at 89 around the tool to provide for fluid flow around the tool seat through the landing nipple. A seal 91 is positioned on the tool at a point spaced from the landing nipple and above the flow port 72 connecting the production tubing with the bypass conduit. A pair of indicator arms or levers 122, 124 depend from the tool below the seat 88 and are biased by springs 123, 130 (FIG. 6) to follow the contour of the tubing as the tool is pumped through the tubing.

The position-indicator portion 87 of the tool is shown in greater detail in FIG. 6. The indicator arm 122 is shown pivotally attached to the tool housing at 131. A projecting tab 132 is formed on the upper end of the lever 122 and extends to the left into the side of the tool housing. The tab rests on top of a lower flanged end 133 of a vertical rod 134 disposed in a bore 136 in the

housing and connected by its upper end to one side of an annular plate 137. The indicating arm 124 likewise is pivotally attached to the tool housing and has a projecting tab portion 124a which is shaped to rest on the flanged end 133 of the piston when the lower end of the arm is cammed sufficiently inwardly by the interior wall of the pipe in which the tool is positioned. The annular plate 137 is normally seated around the upper end of the tool housing when either of the tabs 132 or 124a is resting on the flange 133. When the plate 137 is seated on the housing it serves to cover a vertical passageway 138 extending through the housing and fluidly connecting the top and bottom of tool 87 above and below the seal 91. A spring 139 positioned below the plate pushes upwardly against the plate to move the plate from its seat over the passageway when the tabs 132, 124a are pivoted away from their normal positions on top of the flange 133. A check valve 141 positioned in the passageway 138 permits fluid to flow from above the tool seal to below the tool seal through the passageway but not in the opposite direction because of the cut away portion 89 in the lower end of the seat 88. This permits the tool to be pumped out of the flow line by the application of reverse flow through the circulating conduit.

It may be determined when the tool is seated in the landing nipple as follows: When the tool seats, the arms 122 and 124 release the piston 134 which in turn permits the plate 137 to lift from its position covering the passageway 138. The spring 139 is of sufficient strength to lift the plate 137 against the differential in hydrostatic pressure between the fluid columns in the flow line above the tool and the fluid column in the circulating conduit which acts on the bottom side of the plate. The spring 139 is not of sufficient strength to lift the plate against this differential pressure, however, so long as pressure is being applied to the flow line to pump the tool into the well. Therefore, it will be necessary to reduce the "pump in" pressure on the flow line above the tool so that the piston 134 will lift the plate 137 from its seat over the passageway 138. Once the passageway is open the pressure will equalize across the tool and the valve will remain open. Subsequently, pressure is again applied to the flow line above the tool. If the tool is seated in the landing nipple 29 and the passageway 138 is open, the fluid above the tool will flow through the passageway 138 and then through the circulating conduit. If, however, the tool is not seated, the passageway 138 will still be closed (since the arms 122 and 124 are still retracted) and as pressure is again applied to the flow line, the fluid column above the tool will begin to pressure up, which pressure can be determined at the surface thereby indicating that the tool is not seated.

If the well is producing light hydrocarbons or gas, it is likely that the pressure in the circulating conduit will be much less than the pressure of the fluid column being used to pump the tool into the well. This large differential in pressure might prevent the spring 139 from lifting the plate 137 from its seat over the passageway 138. If such a situation is expected, the ball in check valve 141 is removed from the valve. Since this will prevent pumping out of the tool after the passageway 138 is open, removal of the ball will now permit reverse flow through the passage 138. When the tool seats on the landing nipple, the arms 122 and 124 are pivoted to release the plate 137. Although the differential hydrostatic pressure may be too great to permit the spring 139 to lift the plate 137 from its seat, flow may now be reversed through the circulating or bypass conduit to apply sufficient pressure to the bottom side of the piston to lift the plate against the hydrostatic pressure of the fluid column in the flow line above the tool. Once the plate lifts the pressure will equalize on both sides of the plate 137 to maintain the passage 138 open. Thereafter, an application of pressure to the column of fluid above the tool will not cause a pressure build up since the passageway 138 is open. If the tool is not

seated and passageway 138 is not open this application of pressure above the tool will cause a pressure build up which will be determinable at the surface to indicate that the tool is not seated.

A bore portion 142 extends through the position indicator portion 87 of the tool assembly for receiving the flexible cable 84 to which the operating portions of the tools are attached. A set screw 143 is laterally positioned in an upwardly extending collar portion 144 of the tool housing. This screw extends into the tool bore to engage the cable and provides a means for moving the cable within the bore 142 and adjusting the flexible cable and operating tool attached thereto with respect to the landing seat on the tool.

Referring again to FIG. 4, the second safety switch device 75a which is positioned below the position indicator portion 87 at the end of cable 84 provides a second diameter indicating switch which when acting in series with the upper switch will give certain assurance that the tool has reached a certain position in the pipe. This lower safety switch portion 75a is positioned on the tool assembly to extend below the landing nipple and is adjusted to close the circuit switch 76 therein when it enters the casing.

The perforating portion 82 of the tool assembly shown in FIG. 4 is comprised of an orienting tool 92 and perforator capsules 93, the tool 92 being attached at its upper end to the lower safety switch 75a. The capsule charges shown depending from the tool may be of the type disclosed in Pohoriles Patent No. 3,100,443. A detonating cord 94 connects the capsules to a blasting cap and firing circuit (not shown) in the tool. The firing circuit is connected, in turn, to electrical wires in the lower safety switch 75a. These wires are connected to wires in the flexible cable 84 which electrically connect the perforating gun to the plug 83 extending upwardly from the tool assembly.

The orienting tool is provided on the gun assembly to ensure proper orientation of the perforators in the event more than one producing pipe is suspended in the well bore. This orienting portion of the gun includes a switch arm 95 which extends to the side of the orienting tool housing. This switch arm serves to close a normally open switch 103 also in the firing circuit when the arm is extended in the enlarged casing bore as shown below the broken line in FIG. 4 and as shown in cross-section in FIG. 5A. It should be noted that the portion of FIG. 4 below the broken line is drawn to a smaller scale than the rest of FIG. 4 for convenience.

The details of the orienting tool and switch mechanism are shown in FIG. 5. The switch includes a cylindrical housing 101 and a switch plug 102 received in the upper end of the housing. At the upper end of the switch plug, an electrical switch 103 is received in a recess 104 in the plug and secured therein by suitable fastening and clamping means. A pair of contacts 105, 106 are connected to an input conductor 107 and an output conductor 108 and arranged to connect or disconnect the conductors. The conductors are included in one line of the firing circuit between a source of power as in the messenger 37 and the perforating apparatus. Accordingly, detonation of the perforating apparatus is permitted only when contacts 105, 106, are electrically connected.

The output conductor 108 extends through a longitudinal bore in the plug into and through the housing and is suitably connected to the perforating apparatus. The contact 106 of the switch is movable and is adapted to be actuated by a slidable tab member 109 to close with contact 105 in the position shown while upward movement of tab member 109 permits a spring to disconnect contacts 105, 106. Tab member 109 is suitably connected to the upper end of a cylindrical actuating rod 111. Below switch plug 102, the rod is enlarged to form an upwardly facing shoulder 112 which limits movement of the rod in an upward direction. The lower end of the rod is bi-

furcated to receive the upper end portion of an upper arm 113. A pin 114 pivotally secures rod 111 to arm 113.

A window 116 formed in the housing permits extension of the upper arm and a connected lower arm 117 outwardly of the housing. The upper arm 113 is pivotally connected to the housing by a pin 118. A tension spring 119 serves to bias the lower end of the upper arm outwardly against the wall of the casing within which the tool is suspended. The lower arm is connected to the upper arm along a slot 121 formed in the upper arm to provide the necessary contraction of the arms within the housing when the tool is oriented in such a direction that the arm engages other tubing strings suspended in the casing. The switch mechanism described above is constructed to close the circuit contacts when the arm 95 is extended within a certain diameter. A lesser or greater extension of the arm will maintain the contacts open.

Referring now to the operation of the apparatus shown in FIGS. 4, 5 and 6, the perforating portion 82 of the tool assembly is positioned below the lower safety switch portion 75a which in turn is connected to a cable 84 extending from the position indicator tool 87. The cable 84 is adjusted to space the tool at a distance from the landing seat 88 on the tool 87 in such a manner as to place the gun at a position opposite the formation to be perforated when the tool is seated in the landing nipple 29. The tool assembly is pumped through the flow line into the producing string as described heretofore in the description of the tool shown in FIGS. 2 and 3. After the perforator gun portion 82 of the tool assembly passes through the landing nipple 29, the arms 122 and 124 on the position indicator portion 87 extending from the gun are contracted within the smaller diameter part of the tubing below the landing nipple to open the passageway 138 in the tool and provide a pressure indication at the surface that the tool is properly positioned in the pipe, the operation of this apparatus having been set forth in detail above. Additionally, the two safety switch mechanisms 75 and 75a at each end of the cable 84 above and below the position indicator will operate upon stopping at a preselected diameter in the pipe to close the switches in the tool and thereby provide a completed firing circuit to the perforating gun. The dash-pot mechanism used in these safety switches will permit the circuit to be closed by the switch in the event that the devices are positioned at a preselected diameter for closing. If the switches should both pass through obstructions in the pipe at the same time, which obstructions represent the closing diameters, the switch would not close unless the tool assembly were stopped at that point due to the dash-pot mechanism in each switch which causes a delay in the operation of the switch.

Therefore, since both switches must be simultaneously operated and for a prolonged period of time, the chances of accidental operation of both switches to complete the firing circuit are negligible.

Subsequently, a messenger tool, such as the one described heretofore with regards to FIGS. 2 and 3, is pumped into the flow line to engage the connector 83 extending upwardly from the tool assembly to provide a power supply to the firing circuit and thereby energize the now closed circuit to fire the perforators.

If upon pumping of the messenger into connection with the tool, the gun does not fire, it may be due to the improper orientation of the perforating tool in the casing and failure of the arm 95 to expand sufficiently to complete the circuit through the tool. As shown in FIGS. 1 and 5a, a plurality of production strings may be suspended in a casing. If the perforating is to occur in a section of casing having one or more producing pipes the arm 95 projecting from the tool may be prevented from expanding to a predetermined diameter to close the firing circuit. This ensures that firing can only occur when the arm is fully expanded which will occur when the tool is positioned as shown in FIG. 5a to fire the gun away from the other tubing strings. The perforating charges are so orient-

ed on the tool that they will fire only in a single direction or through a fixed arc as indicated by the arrows at A in FIG. 5a, thus preventing accidental perforation of the other tubing strings.

If the gun is improperly oriented preventing the switch arm 95 from fully extending, the tool may be reoriented as follows: Circulation is reversed through the circulating conduit to lift the tool slightly whereupon tension is applied to the cable 84 from which the gun is suspended. This tension in the cable will cause the cable and depending gun to rotate into a position where the arm 95 can fully expand to close the firing circuit in the perforating gun.

It should be pointed out that the two safety switches 75 and 75a positioned above and below the landing nipple should give completely safe control over the firing circuit and that no other safety devices or indicators would necessarily need to be used to perform a perforating operation. Therefore, if the power supply messenger were connected to the perforating apparatus at the surface before pumping the apparatus into the well, the safety switches 75a would operate upon reaching the right combination of diameters to close the electrical circuit in the tool and fire the perforating gun. This would also be true of combinations of the safety switch devices and the orienting tool.

If the messenger is to be pumped into the flow line after the tool has been properly positioned to perform the perforating operation, the position indicator portion 87 of the tool should be used to provide a surface indication that the tool is properly positioned.

The orienting portion of the tool shown in FIG. 5 would be used if orientation of the perforations were necessary due to other pipe strings being present in the well as for example in the case of a dual-completion well.

It should be pointed out that the position of the tool in the flow line may be fairly accurately determined by the measurement of the displacement of fluid in the pipe system as the tools are being pumped through the flow line. By measuring the fluid displaced through the circulating pipe as the tool is being pumped in the flow line, the volume of fluid may be correlated with the size of the pipe to provide information indicative of the tool position.

Now referring to FIG. 7, a dump bailer 150 is shown suspended from the flexible cable 84 beneath a positioning tool such as that shown in FIG. 6. The lower end of the bailer is closed by end plate 151 to hold a cementing material 152 in the bailer. An umbrella-type basket 153 is connected to the bottom of the dump bailer by means of a holding member 154. The umbrella basket is of standard construction and consists of finger members 156 which are arranged to be spring biased into engagement with collars in the interior of the casing. A thin, resilient insert 157 may be located within the basket to facilitate the retention of material dumped into the basket. One or more small explosive charges 158 are positioned on the bottom end plate of the dump bailer adjacent the holding member 154. Upon a pressure indication at the surface that the position indicator tool 87 has been seated properly in the landing nipple, an electrical signal is supplied to the apparatus either from the tool or by way of a messenger apparatus pumped to the tool. This electrical signal, in turn, detonates the explosive charge 158 which disintegrates the holding member 154 and bottom end plate 151 of the dump bailer. Upon disintegration of the end plate, the cementitious material 152 is dumped from the bailer into the umbrella-type basket 153 formed by the fingers 156 to form a plug on top of the basket. To facilitate dumping of material from the bailer, one or more ports 149 is provided at the upper end of the bailer to permit pressure to enter the top end of the bailer above the cement. Light flexible seal members 155 are placed over the ports and are

arranged to fold or swing over the port if the bailer should be inverted as when passing through the radius 26 in the flow line above the wellhead (FIG. 1). However, when the bailer is positioned as shown in FIG. 7 the seals flap downwardly to uncover the ports and expose the cement to hydrostatic pressure.

FIG. 8 shows a dump bailer having a cylindrical housing 161 which is filled with a cementitious material 162 and having a releasable closure member 163 pivotally attached to the lower end of the housing. A trip lever 164 has an arm 166 extending therefrom which serves to hold the closure member 163 in the transverse position across the lower end of the cylindrical housing 161. The trip lever is comprised of a latch mechanism similar to that utilized in the positioning apparatus shown in FIG. 5. Upon the passing of the bailer through the landing nipple, a lower end 167 of the lever is forced inwardly by the smaller diameter or more restricted side of the landing nipple to pivot the lever arm 166 outwardly and release the pivoted closure element 163 in the tool thereby facilitating dumping of the cementitious material from the tool into the casing. The closure member is pivoted at a point offset from the center to sufficiently unbalance the closure member to permit its pivoting due to the weight of the cement. Ports and flexible flap-type seals (not shown) similar to those shown on the bailer in FIG. 7 are provided on the upper end of the housing 161 to facilitate dumping of the cement.

FIG. 9 shows a system for logging well utilizing TFL tool techniques. A logging tool 171 is shown connected to the lower end of the cable 84. The cable in turn is shown suspended from a position-indicator tool 87 such as that shown in FIG. 6. A casing collar locator 172 is positioned above the logging tool. A recording apparatus 173 is attached to the other end of the cable above the positioning tool 87. Another casing collar locator and/or a gamma-gamma logging tool 176 is affixed to the recording tool. The position-indicator tool is the same as that shown and described in reference to FIG. 6 including a seal member 91 to provide sealing engagement between the tool and the tubing and to facilitate pump-in and pump-out of the tool through the flow line. A safety switch such as the one shown in FIG. 14 is attached to the logging tool 171 to provide an electrical indication of the moment the logging tool passes through the landing nipple 29. This electrical signal serves to activate the logging tool and recorder to begin the log at that moment. When a pressure indication is received at the surface that the position-indicator tool 87 has seated in the landing nipple, it is then known that the logging tool has reached its maximum depth and that the tool may then be brought out. It may be desirable to start the log at the bottom and log up in which event the activation of the logging tool would be initiated when the positioning tool has been seated as evidenced by a pressure increase above the positioning tool. This increase in pressure is due to the fluid being bypassed through the rather small passageway 138 which normally should create a higher pressure than the drag on the tool itself would create from being pumped through the flow line. The power supply for the logging and recording instruments may be self-contained in the instruments or provided by a messenger apparatus such as the one described with reference to the perforating apparatus in FIGS. 2 and 3. If, for some reason, the location of the seating nipple is lost in relation to a given formation, it would be possible using the tool shown in FIG. 9 to relocate the formation in relation to the seating nipple.

The landing device would signal (hydraulically or otherwise) the operator that it was on the landing nipple. This signal could also be made to start the downhole recording system, or the downhole recording system would be made to run during the entire operation. Alternatively the system could be constructed to operate

after a predetermined time lapse as by a timing mechanism. It would be possible to establish a time on the log when the landing device would be in the seating nipple. By reversing circulation, the logging device would be lifted. If a known amount of fluid were pumped into the well at a constant rate, it would lift the logging device at a constant speed. The casing collar locator in the tubing would log the collars in the tubing. The distance between the collars, of course, is known (from oil company records—usually a nominal 30 ft.). The log would then indicate a series of collar locations separated by time which information could be converted into feet. At the same time, the logging device below the tubing would be logging and recording either collars and/or formation behind the casing, as the case may be, and would, of course, also indicate the seating nipple when the lower unit entered the tubing. With the two logs, the distance of any formation could be re-established in relation to the seating nipple. A positioning device might be provided on the casing collar locators to push the tool against the casing wall so as to facilitate location of collars in the casing.

Referring next to FIG. 10, an apparatus is shown for reaming unconsolidated sand in the casing and for cleaning the landing nipple. The apparatus comprises a cylindrical flexible housing 181 having an enlarged housing portion 182 on its upper end. A flexible shaft 183 is mounted lengthwise through the cylindrical housing and is supported at either end and intermediate its ends by bearing members 184 mounted on plates in the cylindrical bore of the housing, each of the plates having openings 186 therein to permit fluid flow through the housing. A fluid-operated turbine having an impeller blade 187 is positioned at the upper end of the shaft in the enlarged housing portion 182 and flexible agitator members 188 are positioned on the bottom end of the shaft below the housing. These flexible members (FIG. 11) are pivotally mounted to permit expansion of the members when rotated due to centrifugal force. A sealing member 189 is positioned around the tool below the impeller housing to permit pumping of the tool in the pipe and operation of the tool from fluid pressure.

An annular flange 180 is formed on the housing below the sealing member 189, the flange providing a seat for the tool in the landing nipple. The flange 180 is cut away as at 179 to provide for fluid flow between the landing nipple and the flange. A spring-loaded foot valve 191 is positioned on the end of the shaft 183 between the agitator members 188 and the lower end of the flexible housing 181. This foot valve prevents flow through the tool as the tool is being pumped down through the flow line. However, once the tool is seated or stopped by sand in the pipe and pressure is applied above the tool, this pressure forces the foot valve open against a spring normally holding the valve closed and fluid flow is established through the tool. The fluid flow returns up alongside the tool through the cut away portion 179 on the flange 180 and out through the bypass conduit. As the fluid circulates, the shaft is driven by rotation of the turbine 187, which rotation is caused by fluid flow through the enlarged housing 182. The flexible agitator members 188 are rotated with the shaft to agitate sand in the casing. Fluid flow, in conjunction with the agitation, causes the sand to be washed from the casing and carried with the fluid flow through the bypass conduit to the surface. It should be pointed out that a more restricted return path for fluid to the bypass conduit may be provided in the tool to ensure that sand will remain in suspension in the fluid.

In the operation of this device the apparatus is pumped into the flow line until the lower end of the tool encounters an obstruction in the well bore at which time additional pressure is exerted on the fluid in the flow line above the tool to cause opening of the foot valve 191 and fluid flow lengthwise through the cylindrical housing

181, entering and exiting through ports 186 formed in the bearing support plates in the bore of the housing. As the fluid passes around the impeller blade 187 positioned on the upper end of the shaft, the blade is caused to turn thereby turning the shaft and the members 188 attached to its lower end.

FIG. 12 shows a power supply messenger and latching arrangement which may be used in place of the messenger apparatus shown in FIGS. 2 and 3. This messenger apparatus shown in FIG. 12 is constructed to be pumped down over the upwardly extending plug portion 193 of a tool. A bore portion 194 is formed in the lower end of the messenger housing 196. A passageway and check valve (not shown) may be provided to extend from the upper end of the bore portion to the outside of the messenger housing to thereby prevent fluid from being trapped in the bore portion upon insertion of plug portion 193 in the bore. Latch members 198 are housed in the bore portion of the messenger and are biased inwardly into the bore to latch under a flanged portion 199 formed on the plug. A beveled edge 201 is formed on the lower edge of the latch members 198 to permit the latches to be cammed outwardly against springs 202 as a sloping head portion 203 of the plug is inserted into the messenger housing. The latch members 198 are positioned in the tool so that they may be inserted or removed by lifting a tang portion 198a into a recess 198b in the tool. The lower end of the latch may then be pivoted into the bore of the tool so that the latch may be inserted or removed through the bore. Spring-contact members 204 are housed in the wall of the messenger housing 196 adjacent the bore portion of the messenger and extend slightly into the bore portion. Electrical circuit wires 206 connect these contact members with an energy source in the messenger. Contact is made between the contacts in the bore portion of the messenger and the plug portion of the tool by the frictional contact of the spring contacts 204 acting against contact discs or sleeves 207 located on the plug portion. Sleeves 207 are connected to electrical conductors 208 connected to the tool which is to be energized. Two outwardly extending sealing elements 211, 212 are shown on the messenger housing 196 at spaced locations and serve to effect a seal between the messenger and the flow line. The purpose of two spaced apart seal elements is to provide a continuous seal in the event one of the seal elements should be totally received within an enlargement within the tubing string thereby causing fluids to bypass the apparatus. As an alternative the seal may be made large enough to insure bridging of such gaps and thereby provide a continuous seal. It should also be pointed out that while only one seal element has been shown on other tools in the drawings, the arrangement of two or more seals might also be used on those tools.

FIGURE 13 shows another device to be used with a TFL tool for indicating when the tool has become seated on the landing nipple in the flow line. The tool has a seal member 216 positioned thereon above a lateral flow port 218 extending midway into the tool. This flow port is connected to a vertical passageway 219 extending through the tool to a second lateral flow port 221 positioned above the seal member 216. A ball 222 is positioned in an enlarged cavity 223 in the passageway and serves to block off the passageway when seated in either end of the cavity. An arm 224 extending upwardly into the vertical passageway is connected through a pivotal linkage 226 to a lateral bar 227 projecting outwardly from the tool below a seating flange 217. The arm 224 is sufficiently long to engage the ball when the lateral bar 227 is raised upwardly.

In the operation of this device, the tool is pumped in through the flow line to be seated on the landing nipple in the producing string. Upon seating thereon the lateral bar 227 engages the seating nipple and is moved upwardly into a recess 229 in the housing and seating flange

217 to produce an upward movement on the arm 224 extending into the vertical passageway 219. This upward movement of the vertical bar into the passageway serves to unseat the ball 222 from the passageway and permit the passage of fluid through the passageway from above the seal member 216 to the lateral flow port 218 intermediate the seal member and the seating flange. This intermediate point between the seal member and flange 217 is aligned with the circulating conduit positioned adjacent to the producing string and fluidly connected to the producing pipe at a point just above the landing nipple as shown in FIG. 2. When the tool seats and is no longer free to be pumped through the flow line, fluid pressure developed above the seal member 216 on the tool is increased thereby providing an indication at the surface that the tool is seated. The opening of the passageway 219 permits circulation through the bypass conduit thus the fluid pressure above the tool will build up only to a certain level at a given pumping rate. This, in turn, indicates to the operator that the tool or member attached to the tool has been seated in the landing nipple. The pressure increase is a result of the limited flow offered to the fluid above the tool through the passageways which limited flow offers greater resistance to fluid flow than the drag of the tool being pumped through the flow line. A reverse flow of fluid through the bypass pipe will cause the ball 222 to cover the upper end of cavity 223 and further reverse fluid flow will cause the tool to move up through the flow line due to fluid pressure under the seal 216. In this way the tool may be pumped back out through the flow line.

The tools heretofore described are particularly suited for use in wells completed with underwater wellhead assemblies requiring the use of TFL tools. However, these tools may also be used in wells completed on land or above the surface of a body of water. Additionally, the tools although again particularly suited for through the flow line use, may utilize features, such as locating and switch mechanisms, which will find use in conventional well tools and maintenance techniques.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications in construction and use of the devices may be made without departing from this invention in its broader aspects and, therefore the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Apparatus adapted to be pumped from the surface through a well bore flow line comprising: a well completion tool sized for movement through a well bore flow line, means on said well tool adapted for providing a seal between said well tool and a flow line so that said well tool may be pumped through a well bore flow line to a prescribed position therein, means providing a passageway for connecting the exterior of said well tool on either side of said seal, normally closed valve means in said passageway, and means responsive to said well tool reaching a prescribed position in a flow line for opening said valve means and providing an indication at the surface of the arrival of said well tool at this position.

2. Apparatus adapted to be pumped from the surface through a well bore flow line comprising: a well completion tool sized for movement through a well bore flow line, means on said well tool adapted for providing a seal between said well tool and a flow line to sustain pumping pressure so that said well tool may be pumped therethrough, means providing a passageway for connecting the exterior of said well tool on either side of said seal, normally closed valve means in said passageway, and means responsive to said well tool reaching a change in the internal configuration of a flow line for opening said valve means and providing an indication

at the surface of the arrival of said well tool at such a change in internal configuration of a flow line.

3. Well bore apparatus adapted to be pumped through a well bore flow line comprising: a well-completion tool sized for movement through a well bore flow line, means on said well tool for providing a seal between said well tool and a flow line to sustain pumping pressure so that said well tool may be pumped through a well bore flow line, means providing a passageway for connecting the exterior of said well tool on either side of said seal, normally closed valve means in said passageway, and means responsive to a change in the diameter of a well bore flow line for opening said valve means and providing a change in such pumping pressure that is detectable at the surface to indicate that said well tool has reached a position in such a flow line having a change in diameter.

4. Well bore apparatus adapted to be pumped through a well bore flow line comprising: a well-completion tool sized for movement through a well bore flow line, means on said well tool for providing a seal between said well tool and a flow line to sustain pumping pressure so that said well tool may be pumped through a well bore flow line, means providing a passageway for equalizing pressures on either side of said seal, normally closed valve means in said passageway, a member exposed to the exterior of said well tool, and means supporting said member on said well tool for movement in response to engagement of said member with an altered portion in such a flow line, such a member being effective upon movement to actuate said valve means to an open position and providing a change in such pumping pressure that is detectable at the surface to indicate that said well tool has reached a position in such a flow line having a change in diameter.

5. A position indicator apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, and a check valve in said passageway for resisting fluid flow through said passageway in one direction.

6. The combination of means for providing an indication of the position of a tool in a well flow line which means comprises: a housing sized for being pumped under pressure through a well tubing, valve means in said housing for placing the space above and below said housing in fluid communication, means on said housing responsive to variations in the diameter of a well tubing for opening said valve means, said valve means providing for fluid flow in either direction through said housing, connector means extending from said housing, and a messenger apparatus arranged to be pumped into and out of a well tubing, said messenger apparatus having a connector member thereon arranged to make a mechanical interconnection with said connector means extending from said housing when said connector means and member are engaged.

7. A position indicator apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, valve means in said passageway, trigger means normally maintaining said valve means closed to block off said passageway, and means responsive to variations in a configuration of the

flow line for releasing said trigger means to open said valve means.

8. Apparatus arranged to be pumped through a flow line comprising: a well tool sized for movement through the flow line of a well, means on said well tool for providing a seal between said well tool and a flow line to sustain pumping pressure so that said well tool may be pumped through a flow line, means providing a passageway for connecting the exterior of said well tool on either side of said seal, normally closed valve means in said passageway, and means responsive to a change in diameter of a flow line for opening said valve means.

9. A position indicator apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, and means responsive to a larger than normal diameter of such a flow line for opening said valve means.

10. A position indicator apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, and a pair of members exposed to the exterior of said housing and movably supported on said housing, said members being responsive to respectively greater and smaller diameters of such a flow line for opening said normally closed valve means in said passageway.

11. A position indicator apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, and a pair of members exposed to the exterior of said housing and movably supported on said housing, said members being responsive to respectively greater and smaller diameters of such a flow line for opening said normally closed valve means in said passageway, said members being arranged to open said normally closed valve means only upon simultaneous response of said members to said respective greater and smaller diameters.

12. A position indicator apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, an electrical firing circuit within said housing for connection to an explosive charge device, and means responsive to the opening of said valve means for arming said firing circuit.

13. A position indicator apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said

housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, an electrical firing circuit within said housing for connection to an explosive charge device, and means responsive to the opening of said valve means for arming said firing circuit, a messenger device for electrically coupling with said firing circuit in said housing to supply power thereto, said messenger device having means for providing a seal between said device and a flow line to sustain pumping pressure so that said device may be pumped through a flow line.

14. A safety switch apparatus for completing an electrical circuit in a well tool in response to the positioning of the well tool, which apparatus is arranged to be pumped through a flow line and comprises: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, electrical circuit means within said housing operable in response to the arrival of said housing at a prescribed position in a flow line.

15. An apparatus for completing an electrical circuit in a well tool in response to the positioning of the well tool, which apparatus is arranged to be pumped through a flow line and comprises: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, electrical circuit means within said housing operable in response to the location of said housing at a prescribed position in a flow line, and a messenger device for electrically coupling with said circuit means in said housing to supply power thereto, said messenger device having means for providing a seal between said device and a flow line to sustain pumping pressure so that said device may be pumped through a flow line.

16. An apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, electrical circuit means within said housing, normally open electrical switch means in said electrical circuit means, and means responsive to the location of said housing at a prescribed position in a flow line for opening said valve means and for closing said electrical switch means.

17. An apparatus for providing an indication of the position of a well tool arranged to be pumped through a flow line comprising: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, normally open electrical switch means in said housing, a member exposed to the exterior of said housing, and means supporting said member on said housing for movement in response to engagement of said member with a variation in the configuration of said flow line for actuating said valve to an open position and for closing said electrical switch means.

18. A safety switch apparatus for completing an electrical circuit in a well tool in response to the positioning of the well tool which apparatus is arranged to be pumped

through a flow line and comprises: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, a plurality of normally open electrical switch means in said housing, a plurality of members exposed to the exterior of said housing, and means supporting said members for movement in response to engagement of said members with variations in the configuration of a flow line for closing said electrical switch means.

19. An apparatus for providing an indication of the position of a well tool and for completing an electrical circuit in said well tool, which apparatus is arranged to be pumped through a flow line and comprises: a free housing sized for movement through the flow line of a well, means on said housing for providing a seal between said housing and a flow line to sustain pumping pressure so that said housing may be pumped through a flow line, means providing a passageway for connecting the exterior of said housing on either side of said seal, normally closed valve means in said passageway, normally open electrical switch means in said housing, a plurality of members exposed to the exterior of said housing, and means supporting said members for movement in response to engagement of said members with variations in the configuration of a flow line for actuating said valve to an open position and for closing said electrical switch means.

20. A combination of means capable of being pumped under pressure into a flow line of a well for perforating the well, which means comprises: a housing arranged for being pumped through a flow line, electrical switch means in said housing responsive to variations in the configuration of a flow line for actuation, perforator means connected to said housing and said electrical switch means, electrical connector means extending from said housing and connected to said switch means, a messenger apparatus arranged for pumping through a flow line into engagement with the connector means, said messenger having a connector member thereon for making an electrical connection with said connector means upon engagement of the connector means and member, and electrical power means in said messenger for supplying electrical energy to said connector member and said perforator means through said electrical switch means.

21. A well tool having a switch therein for completing an electrical circuit in the well tool in response to the positioning of said tool which is arranged to be pumped through a flow line and comprises: a wall-engaging member exposed to the exterior of said tool, means supporting said wall-engaging member for movement in response to a variation in the configuration of said flow line, electrical switch means in said tools, means operably connected between said wall-engaging member and said switch means for operating said switch means in response to the movement of said wall-engaging member at a selected configuration in a flow line, and means forming a part of said operably connected means for slowing the operation of said switch means in response to the movement of said wall-engaging member.

22. A well tool having a switch therein for completing an electrical circuit in the well tool in response to the positioning of said tool which is arranged to be pumped through a flow line and comprises: a wall-engaging member exposed to the exterior of said tool, means supporting said wall-engaging member for movement in response to a variation in the configuration of a flow line, a first movable cam means positioned in the tool, a first linkage means connecting said cam means and said wall-engaging member, cylinder means in the tool for receiving a fluid, piston means slidably received in said cylinder, a port formed through said piston permitting fluid in said cylinder to bypass said piston in a controlled flow as said piston slides in said cylinder, a second movable cam means

attached to one end of said piston, electrical switch means responsive to movement of said second movable cam means for opening and closing an electrical circuit through the tool, a spring adjacent one end of said piston for urging said piston to move in said cylinder, a movable stop adjacent the other end of said piston for preventing said piston from moving in said cylinder, and a second linkage attached to said stop, said second linkage responsive to movement of said first cam means for moving said stop and thereby permitting said piston and second cam means to move.

23. In a well tool capable of being pumped under pressure into a flow line of a well for perforating the well; a housing having a plurality of articulated sections, seal means on said housing to permit said housing to be pumped through a flow line, electrical switch means in one of said sections, said switch means being responsive to variations in the configuration of a flow line for operation, perforator means mounted on a flexible member for movement through a flow line, said perforator means being connected to said housing and said electrical switch means, and electrical power supply means in one of said sections for supplying electrical energy to said perforator means through said electrical switch means.

24. The apparatus of claim 23 and further including a plurality of electrical switch means responsive to variations in the configuration of a flow line.

25. A well tool sized for pumping through the flow

tube of a well comprising: a housing having end connecting means for attachment of said housing to a string of tools, seal means on said housing, electrical circuit means in said housing, electrical switch means in said housing, a flow tube contacting member movably mounted on said housing, means for urging said contacting member into engagement with a flow tube, an actuating member connected to said contacting member, said actuating member having a portion for operating said electrical switch means, and means for connecting said circuit means to an electrical circuit in another housing.

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